Electromagnetic production of kaons from the proton in the Regge-plus-resonance model

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HUGS
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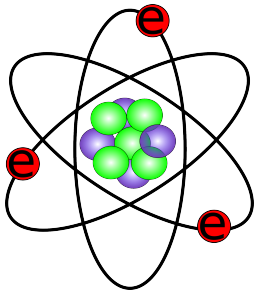
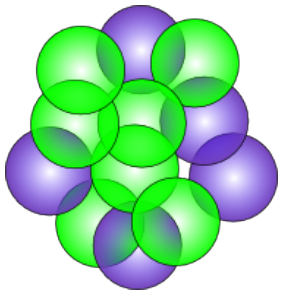
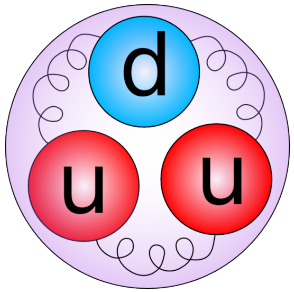
Spectroscopy







Atomic Spectroscopy:

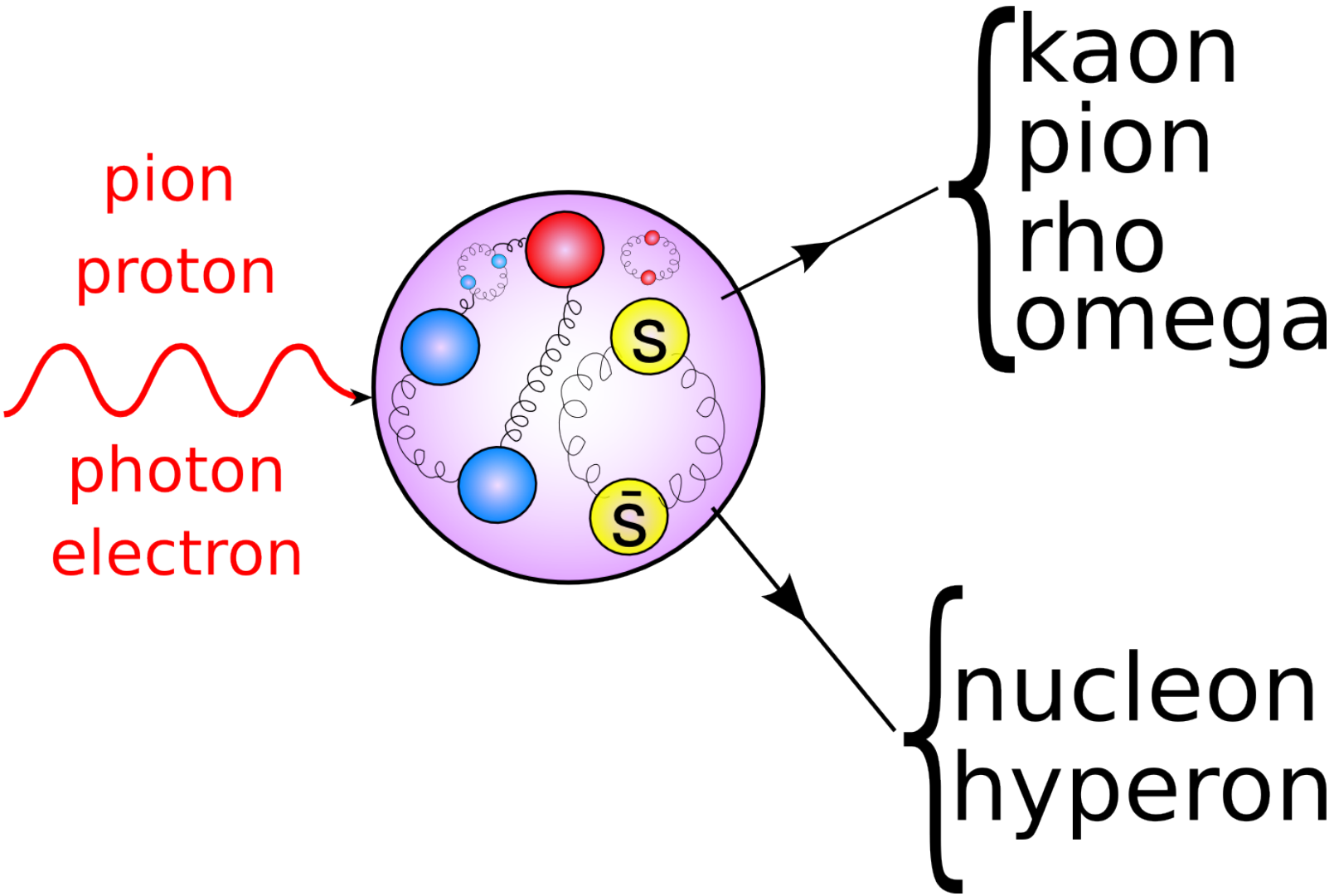
- First test-case for QM
- many applications (MOT,...)

Nuclear Spectroscopy:

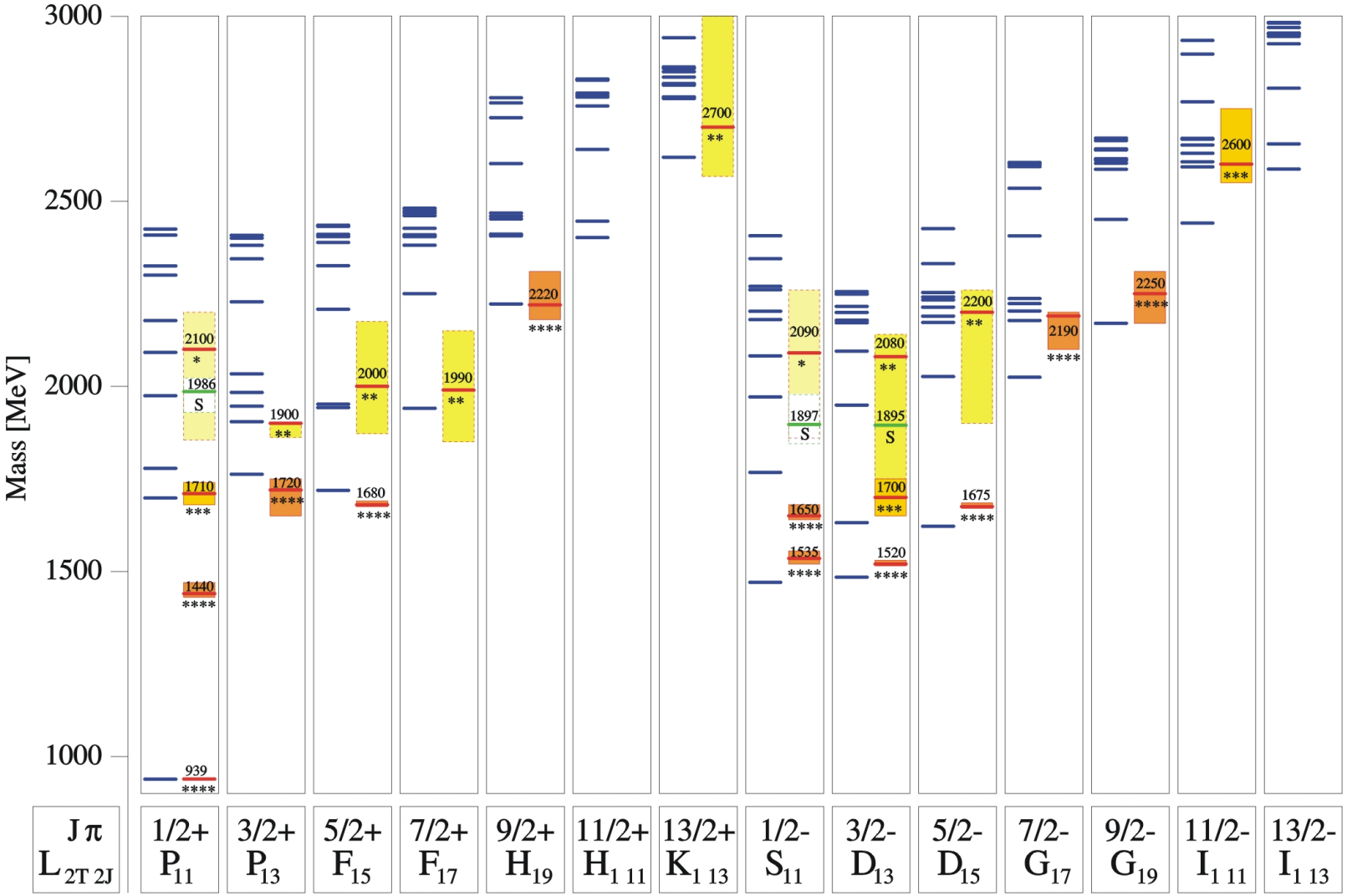
- Learn to solve the many-body problem
- Test N-N and 3-N forces

Nucleon Spectroscopy ?

Nucleon Spectroscopy

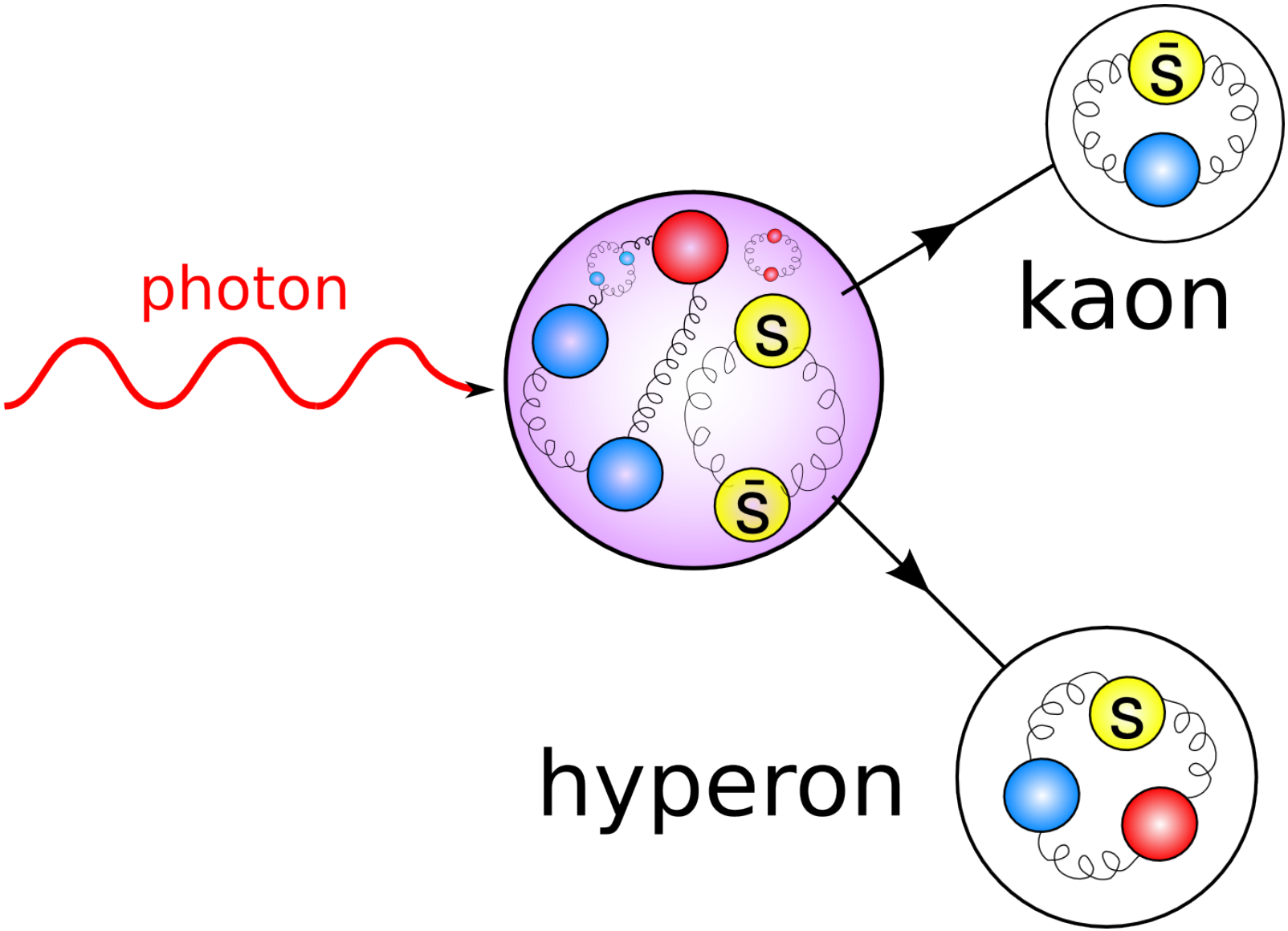


Nucleon Spectroscopy

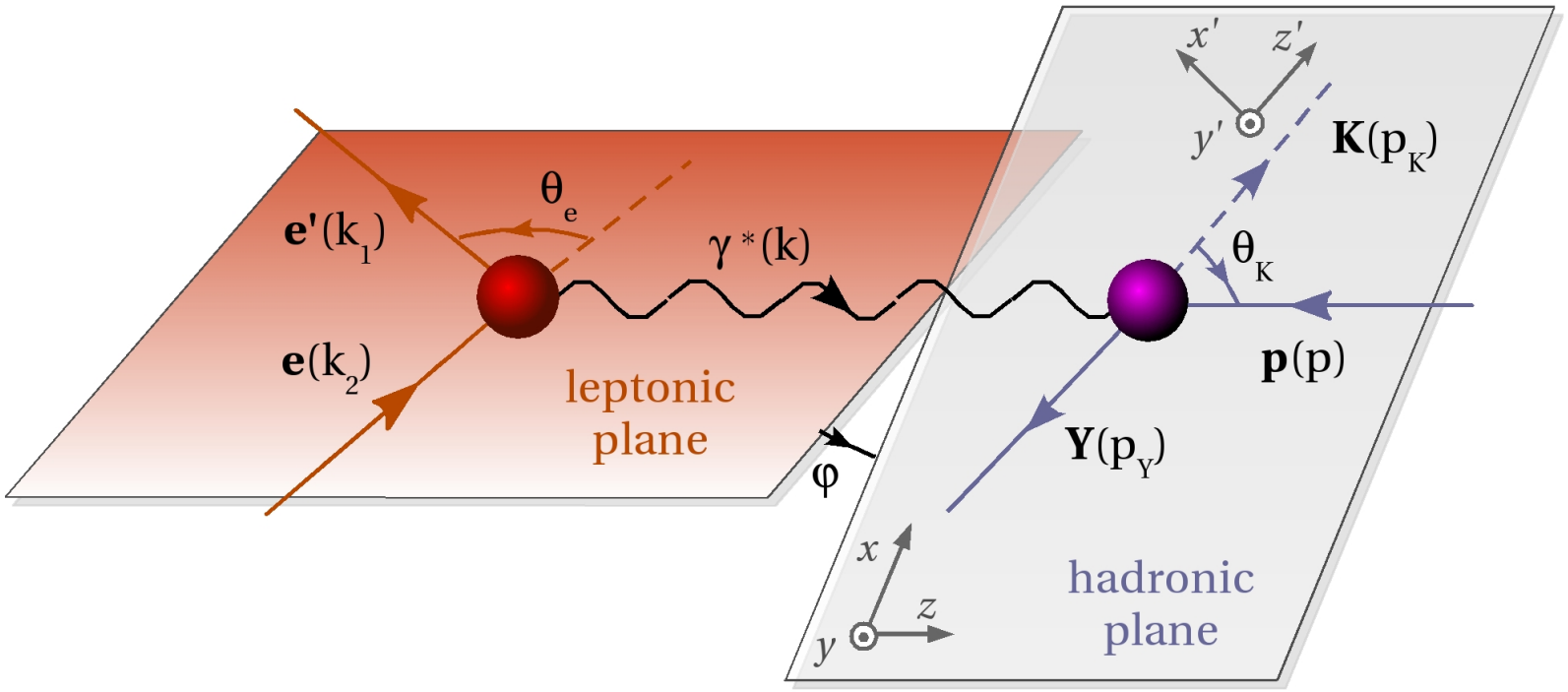


B. Metsch et. al. Eur. Phys. J. A 10, 395 (2001)

Nucleon Spectroscopy

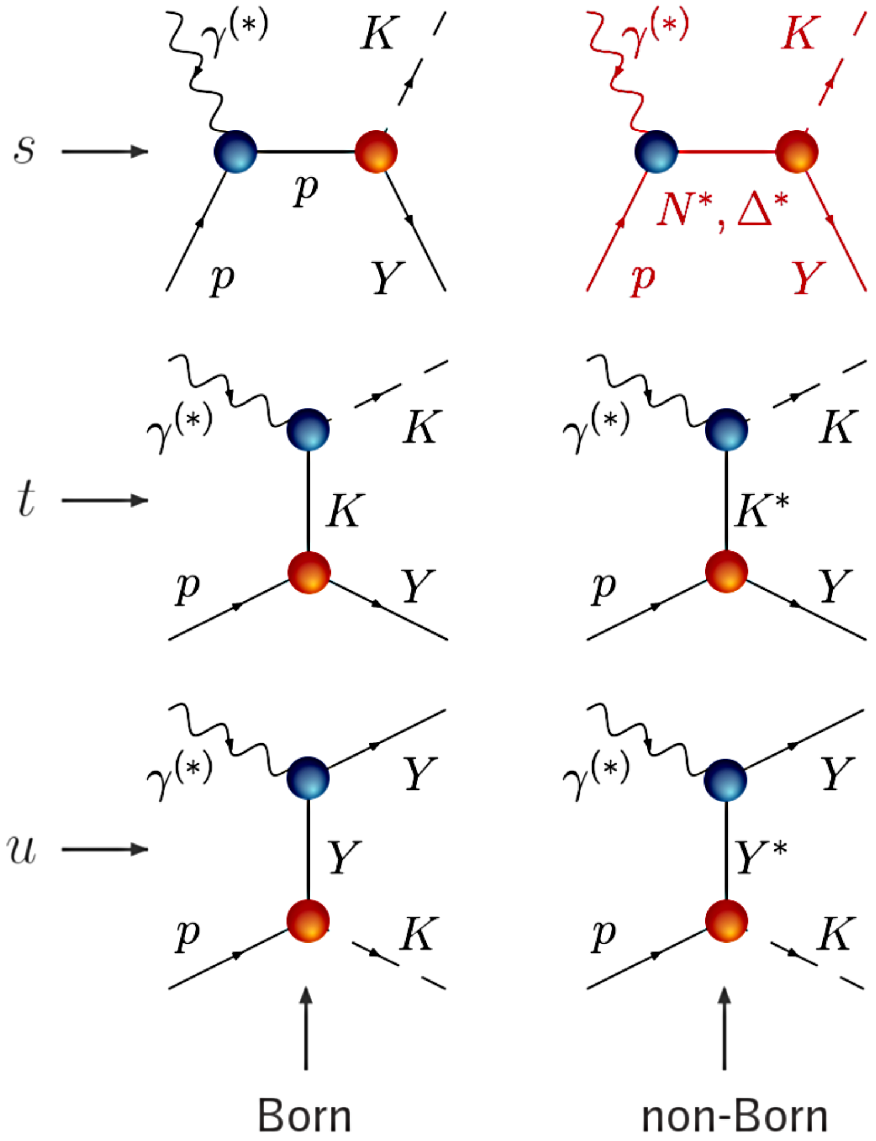


Formalism: Kinematics



$$\frac{d\sigma}{d\Omega_K^*} = \frac{1}{64\,\pi^2}\,\frac{|\vec{p}_K^*|}{\omega^*}\,\frac{1}{(\omega^* + E_p^*)^2}\,\overline{\sum}_{\lambda,\lambda_i,\lambda_f} |\mathcal{M}_\lambda^{\lambda_i,\lambda_f}|^2$$

Formalism: Isobar model



- Hadrons as effective degrees-of-freedom
- Effective Lagrangians obey essential QCD symmetries
- Feynman diagrams at tree-level
- Valid in resonance region: threshold $< \sqrt{s} <$ 2.5 *GeV*

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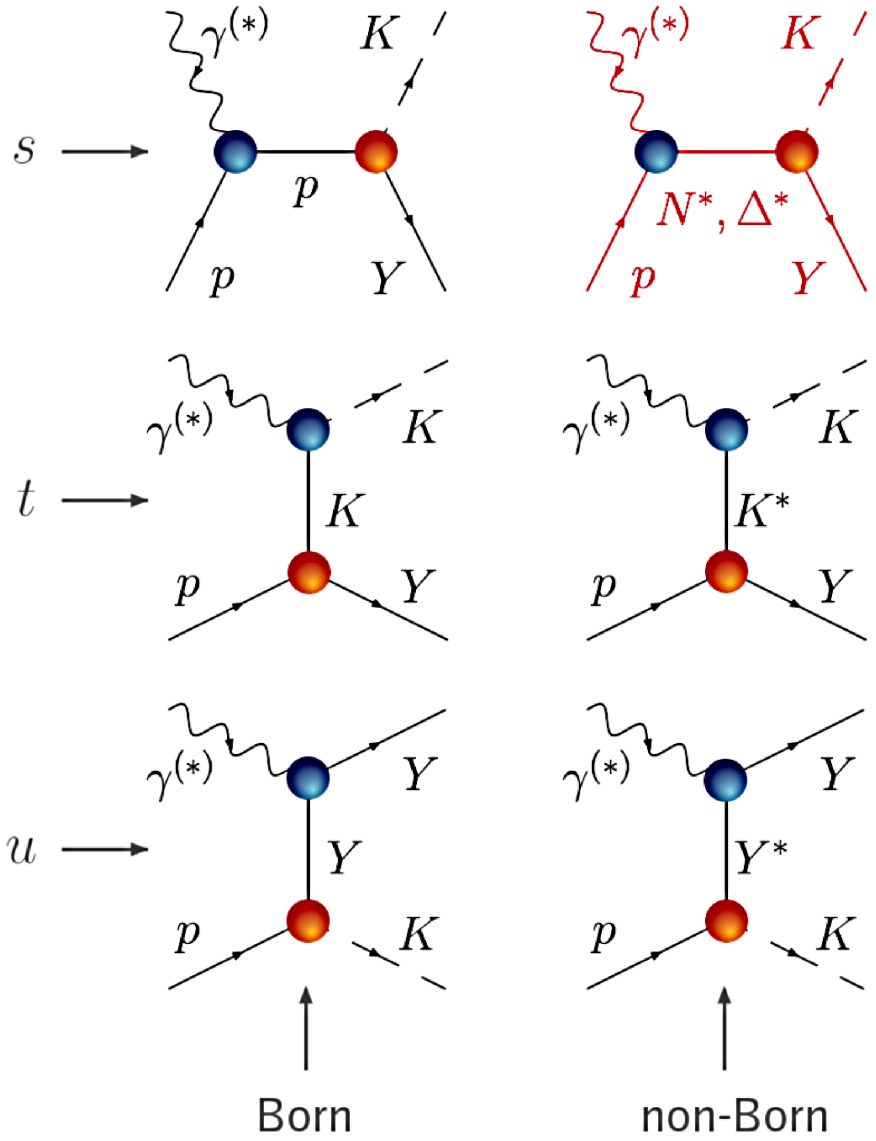

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- Valid in resonance region: threshold $< \sqrt{s} <$ 2.5 *GeV*

Limitations

- Fails at higher energies
- Background is not uniquely determined

Formalism: Regge theory

REGGE $\neq$ REGGAE

- No conferences in Jamaica
- No marihuana involved

Introduction to Complex Orbital Momenta.

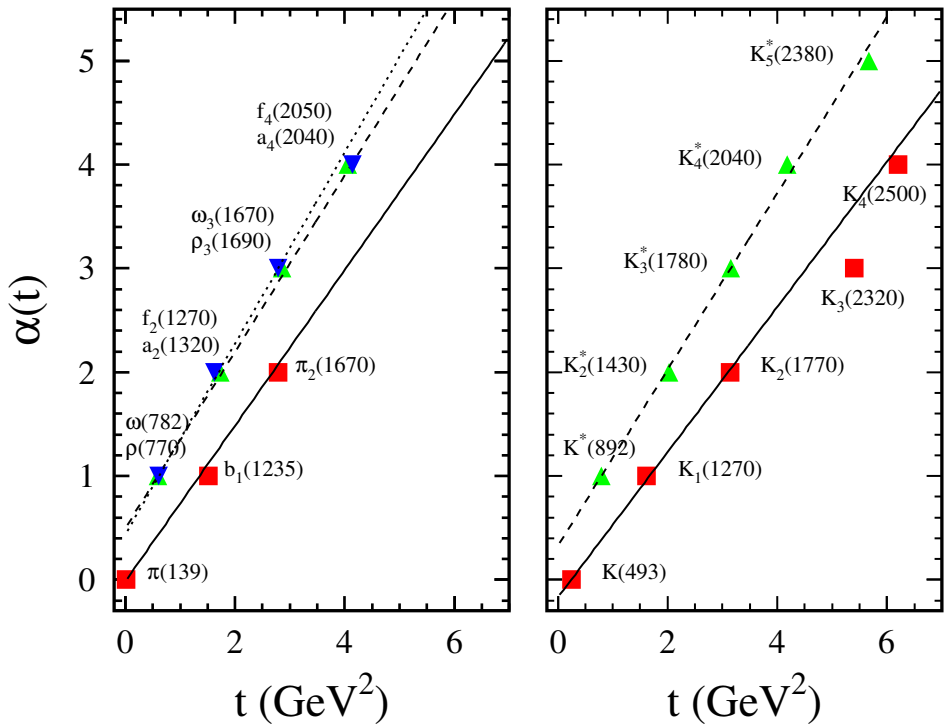
T. REGGE

Max-Planck-Institut für Physik und Astrophysik - München (•)

(ricevuto il 18 Luglio 1959)

Summary. — In this paper the orbital momentum j, until now considered as an integer discrete parameter in the radial Schrödinger wave equations, is allowed to take complex values. The purpose of such an enlargement is not purely academic but opens new possibilities in discussing the connection between potentials and scattering amplitudes.

Formalism: Regge theory



Regge trajectories

Hadrons belong to classes with:

- same internal quantum numbers, but different spins J
- linear relation between squared mass (m_i^2) and spin (J_i) of members of a class

$\rightsquigarrow$ "Regge trajectory" $\alpha(t)$ with $\alpha(t = m_i^2) = J_i$

Formalism: Regge theory

Modeling Regge-trajectory exchange

Modify the intermediate-particle propagator

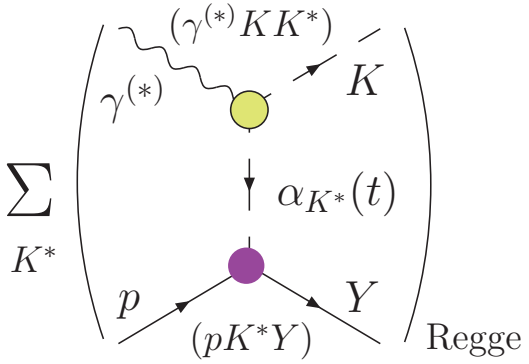
Isobar: $\mathcal{P}^{K^*}_{isobar}(t) = \dfrac{1}{t - m^2_{K^*}}$

$\downarrow$

Regge: $\mathcal{P}^{K^*}_{Regge}(s,t) = \dfrac{s^{\alpha_{K^*}(t)-\alpha_{K^*,0}}}{\sin[\pi\alpha_{K^*}(t)]}$

$$\left\{ \begin{array}{c} 1 \\ e^{-i\pi\alpha_{K^*}(t)} \end{array} \right\} \frac{\pi\alpha'_{K^*}}{\Gamma[1+\alpha_{K^*}(t)-\alpha_0]}$$

P.D.B. Collins, An Introduction to Regge Theory and High-Energy Physics



$$s = (p_p + p_\gamma)^2 = W^2$$
$$t = (p_p - p_K)^2 = p^2_{K^*}$$

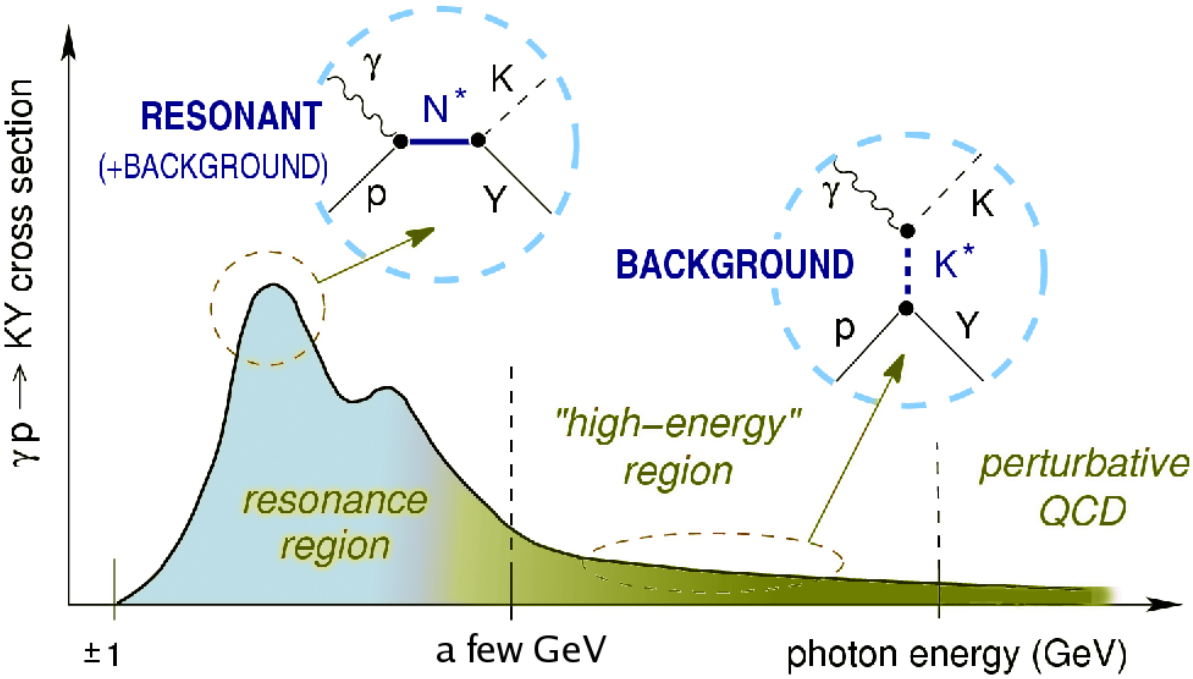
$$\alpha_{K^*}(t) = \alpha_{K^*,0} + \alpha'_{K^*}(t - m^2_{K^*})$$

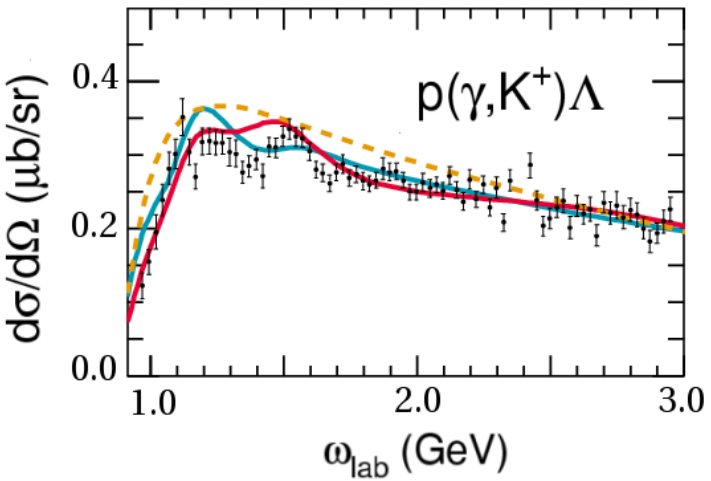
isobar propagator $\longleftrightarrow$ **Regge propagator**

- single pole in t
- cross sections increase unrealistically with energy
- purely real

- series of poles, one per trajectory member
- s-dependence leads to cross sections decreasing with energy
- either constant or rotating phase

Formalism: Regge-plus-resonance





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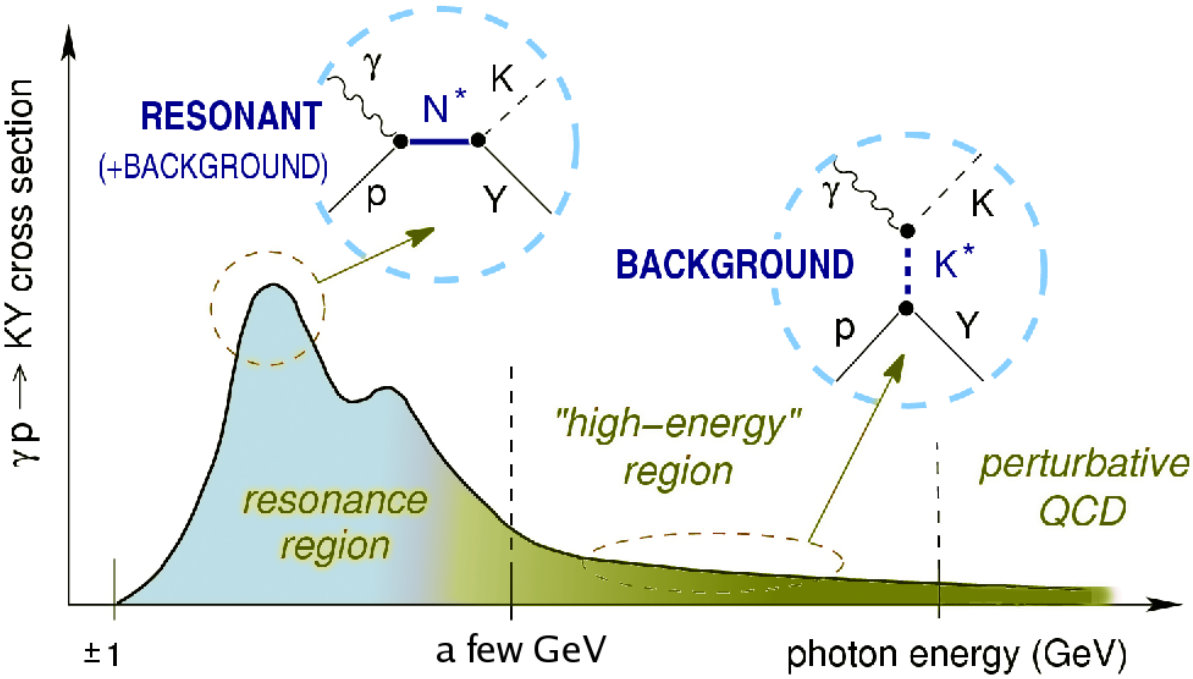
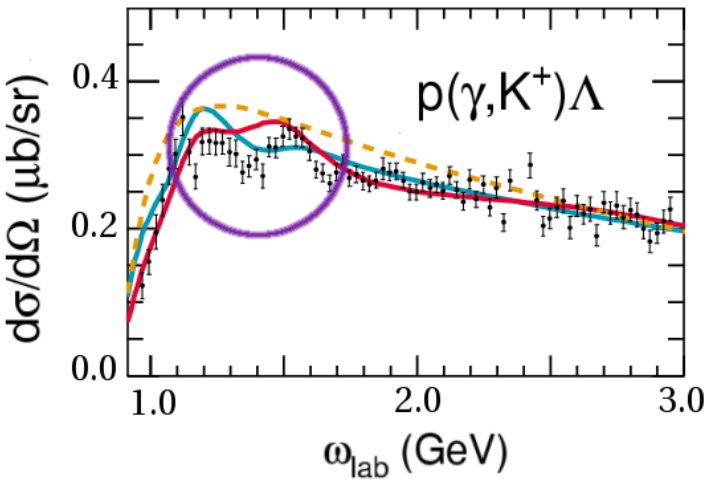


Resonance region:

- both resonant and background contributions
- traditionally described by isobar models

BUT no unique determination of the background!



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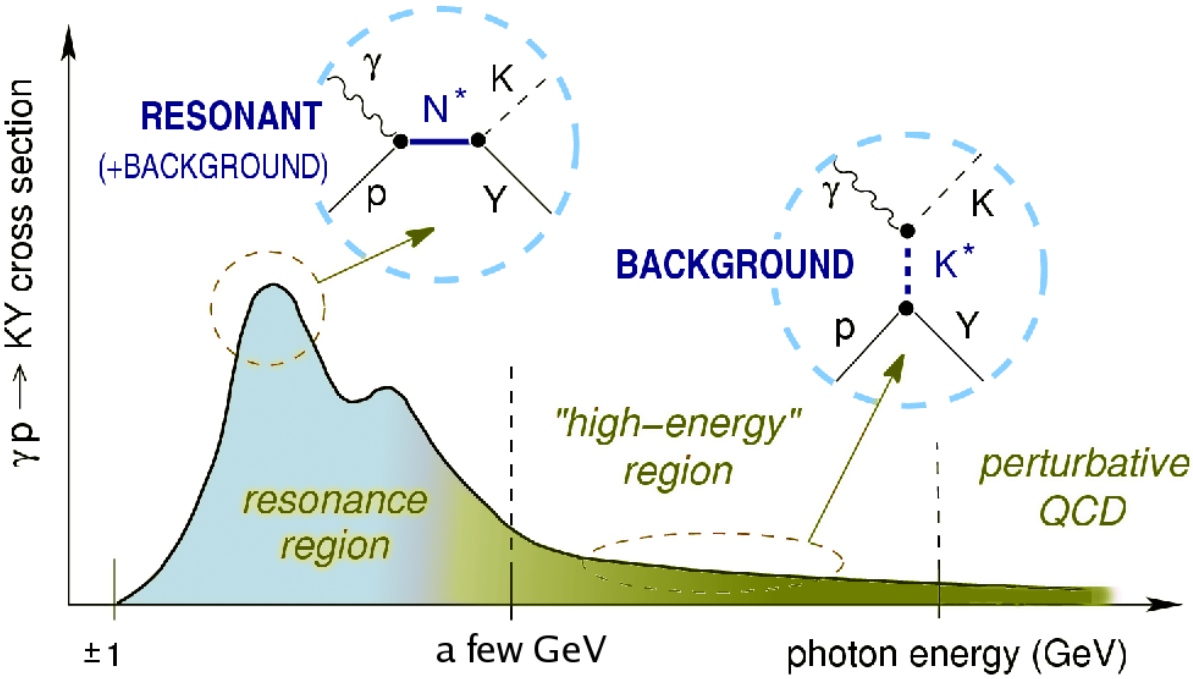
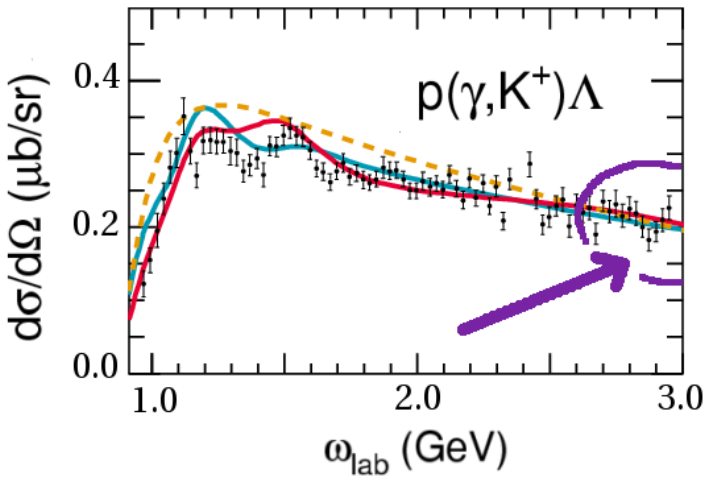


High-energy region:

- only background contributions
- can be described in Regge model



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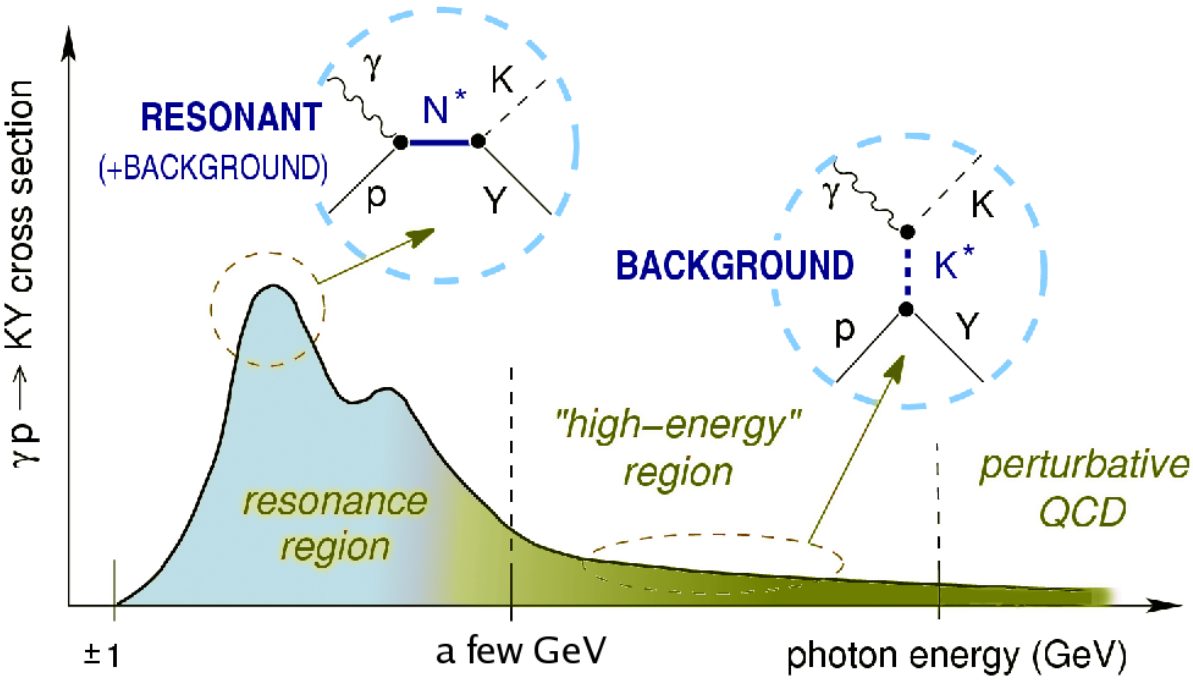

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- both resonant and background contributions
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High-energy region:

- only background contributions
- can be described in Regge model

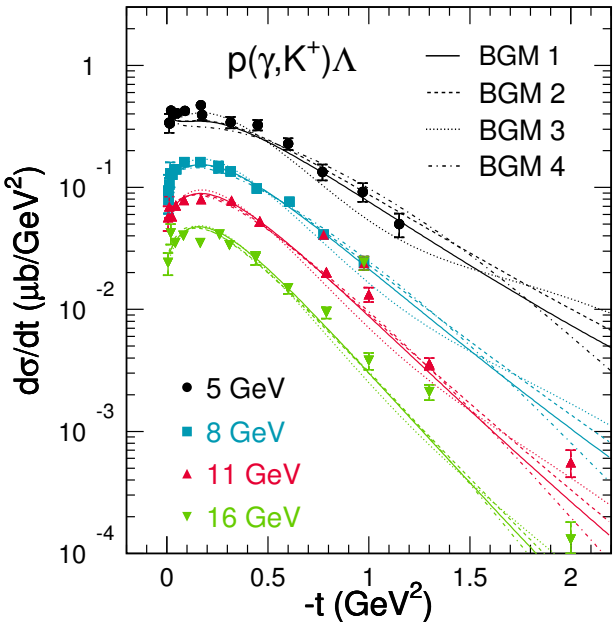
⇓

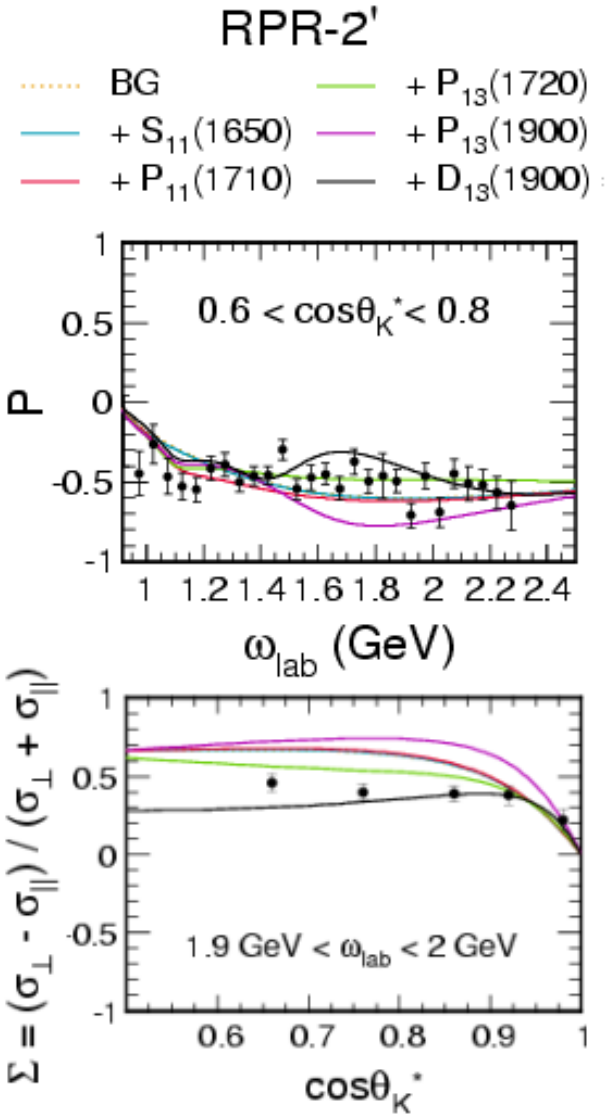
⇒ **Combine isobar and Regge models**

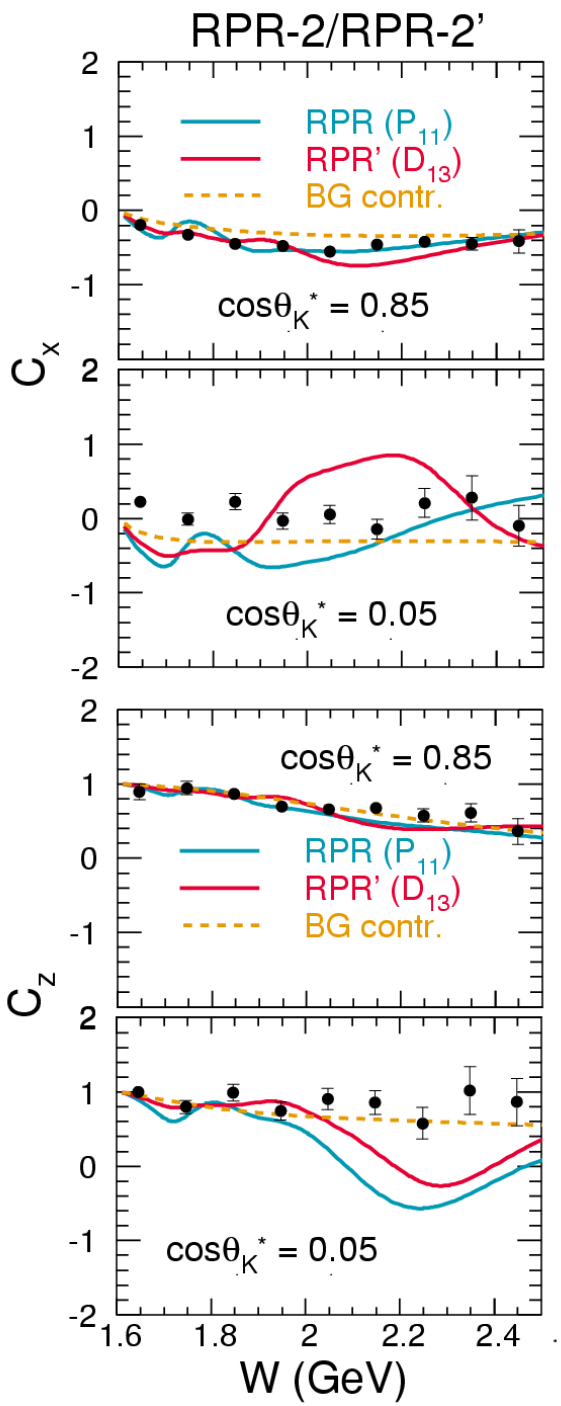
create model valid in both energy regions

⇝ more data with which to constrain the parameters

Results: $K^+\Lambda$ Photoproduction

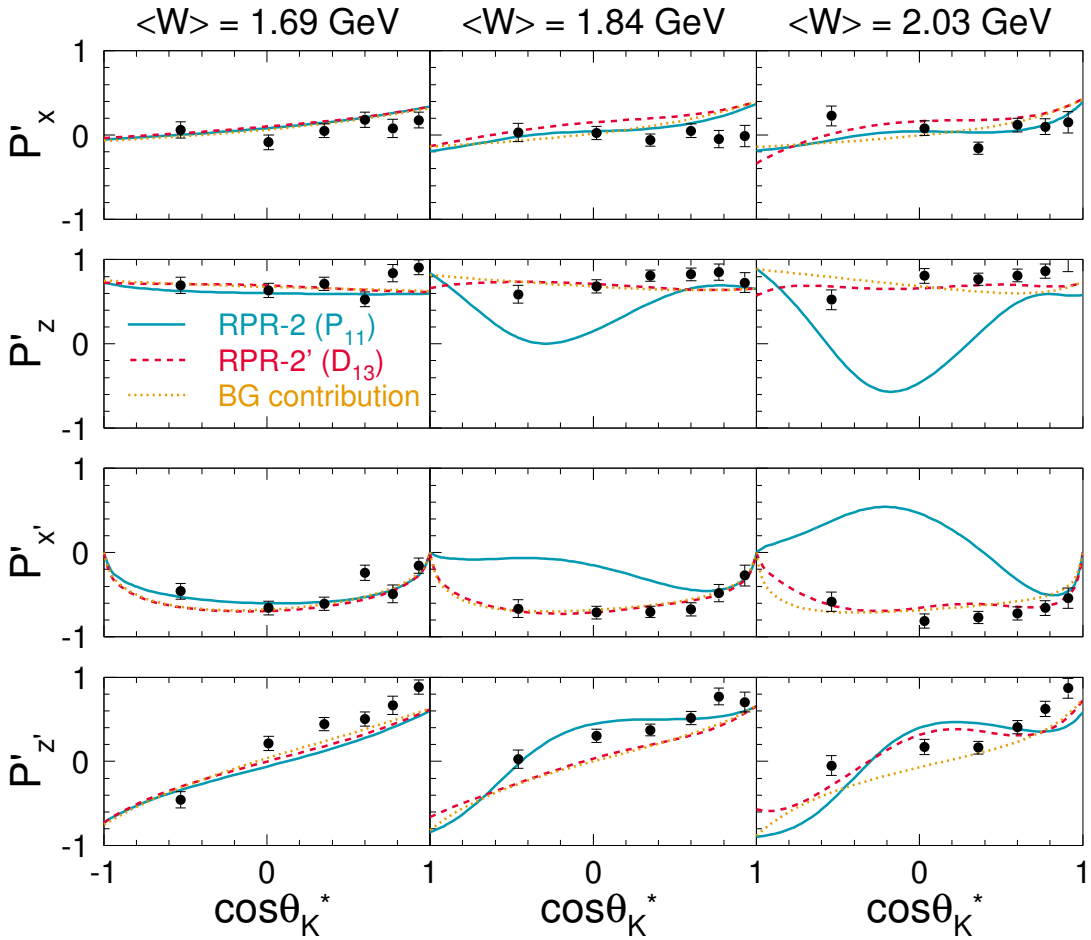






- Exchange of K-trajectory and $K*(892)$-trajectory
- Established PDG resonances with a missing $P_{11}(1900)$ or $D_{13}(1900)$

Results: $K^+\Lambda$ Electroproduction



Remember these results are predictions!

Summary and outlook

RPR framework for kaon production from the proton

- $\rightsquigarrow$ "Regge-plus-resonance"
  - **high energies:** background diagrams, assuming Regge propagators
  - **resonance region:** add N^* and Δ^* diagrams
- $\Rightarrow$ economical description of background contributions
- $\Rightarrow$ RPR amplitude is fully determined by available data $\leftrightarrow$ isobar models

What needs to be done:

- combined fit to photo- and electroproduction data
- have a closer look at polarization observables
- exploit isospin symmetry and study kaon production off the neutron (deuteron)